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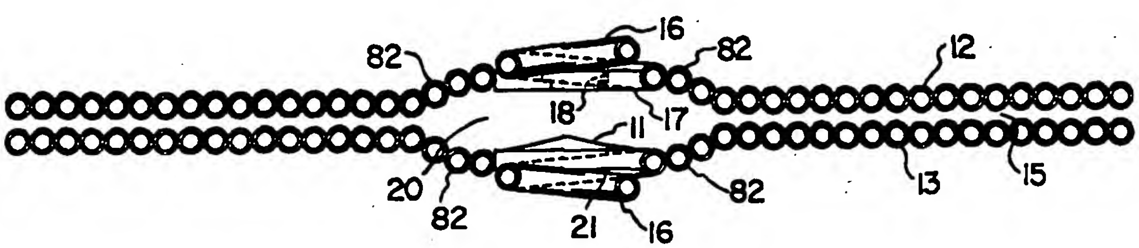

(57) Abstract

A pulse combustor of a type having a combustion chamber (20) in the center between two spaced apart walls (12, 13) and an exhaust region (15) between the plates which surrounds the combustion chamber and extends outwardly therefrom. The combustor has first (12) and second (13) spaced apart walls each formed of hollow tubing wound in a spiral from the combustion chamber outwardly, and a fuel inlet in the combustion chamber. An ignition rod has an electrode which extends into a nozzle at an entrance of a combustion chamber proximate an incoming fuel passageway and initially ignates the fuel therein in order to start the combustor.

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PULSE COMBUSTOR AND BOILER FOR SAME

FIELD

The present invention relates to a pulse combustor and a boiler which employs the pulse combustor.

BACKGROUND

A pulse combustor is a device in which a mixture of air and fuel is initially ignited by, for example, a ignition rod. The ignited gases expand rapidly with an associated rapid increase in pressure and temperature. A resultant pressure wave travels down the device expelling the burnt gases out of an exhaust region. Heat exchange occurs at the walls of the device cooling the gases and enhancing the pressure drop occurring after passage of the pressure wave. This pressure drop due to expansion of the gases combined with the cooling caused by heat exchange at the walls causes new gases to be drawn into the combustion chamber. At the same time the flow in the exhaust region reverses and compresses the new air and gas mixture and with the temperature in the combustion chamber still being high ignition occurs once again.

U.S. Patent No. 4,968,244 issued to the Inventor herein, Mehrzad Movassaghi, describes a pulse combustor with a radial exhaust chamber and a carburetor coupled to the combustion chamber for injecting a pre-determined distribution of fuel mixture into the combustion chamber. The design of the casing of the exhaust chamber comprises an inside disc and an outside disc juxtaposed thereto with an inside disc and outside disc located on each side of the combustion chamber. The exhaust chamber has a spiral groove in the inside disc which is covered by the outside plate forming a coolant passageway. The usage of a disc and plate bonded together with a spiral groove in the disc makes construction difficult and expensive. Moreover, the rapid heating and cooling stresses the bonding between the disc and plate making the device susceptible to coolant

leaks. Finally, the somewhat complex design of the carburetor adds to the expense of the device.

In any known heat generation system used in either a boiler or furnace, control is achieved by turning the heat generating system on and off. When the temperature exceeds a preset threshold, the system is turned off and allowed to cool. Similarly, once cooling has lowered the temperature below a threshold, the system is restarted. Obviously, heating above the threshold on heating up and cooling below the threshold on cooling down are inherent in such a control system. The constant cycling between the temperatures at shut-off and turn-on contribute to high thermal stresses which reduce the life expectancy of the material.

Accordingly, it is an object of the invention to provide a less costly, more efficient and reliable radial pulse combustor than is presently known. It is a further object of the invention to provide a boiler which utilizes the aforesaid pulse combustor and in which control of the output temperature is applied continuously.

SUMMARY OF THE INVENTION

According to the invention there is provided a pulse combustor having a central combustion chamber surrounded by an exhaust chamber, wherein a portion of the combustion and exhaust chambers are formed between two spaced apart walls of spiral wound coolant tubing. The coolant tubing which forms the walls provides much greater heat transfer area while at the same time considerably simplifying the construction of the combustor. In order for there to be a coolant leak in such a design, there would have to be a perforation in the tube itself. A fuel nozzle is located at an inlet to the combustion chamber and a spark generator is provided in the combustion chamber and proximate the nozzle in order to ignite the fuel entering the pulse combustor upon startup.

Preferably, the pulse combustor has a radial design with a circular combustion chamber and circular tail pipe region surrounding the combustion chamber. However, other shapes could be used such as a generally rectangular combustion chamber with rounded edges and a similar shape for the tail pipe region surrounding the combustion chamber. Adjacent tubes are welded so that there is no leakage of exhaust gases between the tubes.

Advantageously, a control system supplies a preset air/gas mixture to the combustion chamber. The system includes a variable speed fan which controls air flow and a gas mass flow regulator which maintains the ratio of air to gas going to the combustion chamber constant. A single temperature threshold is established such that when the temperature of the coolant exiting from the boiler approaches the threshold, the fan speed is reduced causing the gas mass regulator to reduce the flow of gas so that the flow of the air/gas mixture into the combustion chamber is reduced, thereby lowering the energy output of combustion. Thus, the pulse combustor does not normally shut off but merely operates with a controlled mass of gas and air mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as other features and advantages thereof, will be best understood by reference to the detailed description which follows, read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front elevation view of the radial pulse combustor;

FIG. 2 is an elevation view of the radial pulse combustor showing the inlet and outlet coolant tubes;

FIG. 3 is an elevation view of the radial pulse combustor showing the inlet coolant tubes;

FIG. 4 is a section view of the pulse combustor in elevation showing the spacing between the walls of tubing;

FIG. 5 is an elevation view in section of the nozzle;

FIG. 6 is an end view of the nozzle;

FIG. 7 is a front elevation view of a boiler assembly which incorporates the combustor with the front panel removed;

FIG. 8 is perspective view of the boiler showing coolant inlets and outlets and the fan;

FIG. 9 is a second perspective of the boiler showing the mass flow regulator and the connection into the combustion chamber of the radial pulse combustor;

FIG. 10 is a schematic diagram showing the boiler control system; and

FIG. 11 is an elevation view of the nozzle assembly.

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

Referring to FIGS. 1 to 4 there is shown the radial pulse combustor **10** which is formed by a pair of spaced apart walls **12** and **13** with each wall made of spiral coolant tubing spiraling outwardly from a central outlet tube **16** to an outer inlet tube **14**. The coolant tubing is stainless steel. The walls **12** and **13** are welded to two central plates **17** and **21**. A gas nozzle receptacle **18** is

formed through the center of a circular plate **17** (see also FIG. 4) fitted into the center of wall **12** into a combustion chamber **20** bounded by plates **17** and **20** and a conical portion **82** of walls **12** and **13**. Tabs **69** welded to the perimeter of each wall **12** and **13** of tubing to provide a means of mounting the combustor **10** and for spacing apart the walls **12** and **13** a predetermined distance. Between each set of tabs **69** there is inserted a spacer (not shown) which provides the required gap between the plates **12** and **13**. An interior surface of plate **21** has a conical surface **11** that faces nozzle receptacle **18**. Conical surface **11** disperses the flame outwardly through the combustion chamber **20**. The volume **15** between the walls **12** and **13** is termed the tail pipe. Water enters each tube **14** of walls **12** and **13** at the perimeter and exits at the center through tube **16** to allow for a counter flow heat exchange process.

Shut off valves **22** and **22a** allow manual closure of the flow into and out of the cooling tubing **14**. The diameter of the combustor **10** is approximately 44.5 inches and is chosen so that the rarefaction waves that reach the perimeter of the tail pipe region **15** and return to the combustion chamber **20**, reach the combustion chamber **20** at the precise time at which a new charge of air/gas mixture is drawn into the combustion chamber **20**. The separation of the walls **12** and **13** is approximately 0.4 inches while in the combustion chamber **20** the sides are inclined at about 25 degrees to a plane passing through the tail pipe region parallel to the walls **12** and **13**. The width of the combustion chamber **20** is approximately 2.34 inches while its diameter is approximately 12.5 inches.

Referring to FIGS. 5, 6, 8 and 11, the nozzle **19** has a lower portion **54** of reduced diameter which fits into a lower portion of receptacle **18**. The nozzle interior has threads **28** at one end which register with the threads (not shown) of a male end of a reducer pipe **61** (see FIG. 11). Pipe **61** couples the nozzle **19** to a pipe **31**. A threaded end

cap **83** having a threaded opening to register with the threads of ignition rod **32** align the ignition rod **32** with the nozzle **19**. A long insulating rod **26** extends from and forms a part of the ignition rod **32** into the nozzle **19**. From the end of rod **26** an electrode **33** protrudes and is bent over into a hook shape at its end with its point flush with one of several radially spaced injection holes **35** that terminate in recess **24** to produce immediate combustion of the air/gas mixture. An annular interior projection **45** (see FIG. 5) is angled towards the end of nozzle **19.**

Referring to FIG. 7, the pulse combustor **10** is mounted inside a casing **30** with its water outlet tubes **16** passing through a top panel **36** of casing **30**. Nuts and bolts (not shown) pass through brackets **86** on the front and rear of casing **30** and through the tabs **69** and spacers (not shown). Referring to FIGS. 8 and 9, pipe **48** couples an outlet **53** from fan **40** to a T-section of pipe **49**. Pipe **49**, in turn, connects to pipe **31**. Mixing of gas and air takes place in pipe **49**. A gas mass flow regulator **44** and gas shut-off valve **52** are located between a gas line **42** coupled to a gas supply line (not shown) and a gas pipe **59**. Pipe **59** couples to coupling **55** which, in turn, connects to pipe **46**. Pipe **46** connects to T-section of pipe **49**. Flow sensors **58** monitor the flow of coolant through the tubing of each wall **12** and **13**.

At the top of the casing **30**, coolant lines **23** and **25** connect to respective outlet tubes **16** of the pulse combustor **10** while coolant lines **27** and **29** connect to respective inlet lines **14**. A high limit temperature switch **39** is coupled to a manifold **34**. Manifold **34** interconnects coolant lines **23** and **25**. A thermocouple **62** is coupled to manifold **34** to measure the temperature of coolant after it has passed through the combustor **10**. Flow sensors **56** and **58** are coupled to the inlet to coolant lines **27** and **29**, respectively. and sense the flow of

coolant into coolant lines **27** and **29** from manifold **36**. A controller **50** (see FIG. 10), housed within electrical box **87**, is coupled to the fan **40**, the ignition rod **32**, and various relays and switches and controls the operation of the system. A duct **47** (see FIG. 8) is provided at the center of the rear panel to allow for the exit of combustion products from the casing **30**.

Referring to FIG. 10, the complete boiler control system includes fan **40** which has an outlet **53** coupled to pipe **48** in which there is located an orifice **51** that enhances the mixing of air with gas. Pressure is sensed at A1 on the upstream side of orifice **51** and on A2 which is on the downstream side of orifice **51**. A second orifice in connector **55** located on the gas line **59** connected to the outlet from the gas mass flow regulator **44** causes a build up of pressure in the gas line **59** after which gas enters pipe **46**. Pressure is sensed at G1 before the second orifice in connector **55** and G2 after the second orifice. The pressure at the points A1, A2, G1 and G2 are continuously measured by the mass flow regulator and based upon the differentials A1-A2 and G1-G2, the flow of gas through the regulator is automatically adjusted for the appropriate air/gas ratio in the mixing chamber inside T section **49**.

A flame probe **41** is located so that its sensor is inside the combustion chamber **20** and is coupled by wire **37** to controller **50**. Flame probe **41** senses the presence of flame in the pulse combustor **10** and sends a signal along wire **37** to advise the controller **50** of this fact.

Controller **50** connects through an air differential switch **68**, a water flow switch **70** and a high temperature limit switch **39** to a contact of relay **80**. The other terminal of the contact of relay **80** is connected to one output of a transformer **76** coupled to line voltage. The other output terminal of transformer **76** is coupled

through thermostat **74** to the controller **50**. A speed control **60** is coupled to fan **40**, across another contact of relay **80**, to an output of a temperature setpoint control **64** and to line voltage. Temperature setpoint control **64** is connected to timer relay **66** and to thermocouple **62** which senses the temperature of outlet coolant from the combustor **10**. Transformer **76** steps down line voltage to 24 VAC. The other end of the latter contact of relay **43** connects to the other solenoid terminal of the gas valve **52**. One contact of the secondary of transformer **76** connects to timer relay **66** while the other terminal connects directly to relay **43**. Thus, when relay **43** is activated and its contacts closed, the output of transformer **76** is applied timer relay **66**. Prior to timing out, the output of timer relay **66** as sensed on lines **57** by temperature setpoint control **64** causes the fan **40** to operate on a low flow basis.

An air gas mixture entering the combustion chamber **20** through the nozzle **19** is ignited by a spark from an end of electrode **33**. The resulting explosion of the air/gas mixture causes a sudden rise in the pressure of the combustion chamber **20**, thus generating pressure waves which expand radially outward towards the perimeter of the coils. This rapid expansion of the gases, together with cooling by means of heat exchange with the walls **12** and **13** through the flow of water, causes a negative pressure (below atmospheric pressure) inside the combustion chamber **20**. At the same time, the pressure waves carrying the combustion products, come to an instantaneous rest at the perimeter of the coils, reverse in direction and travel radially inward, in the form of rarefraction waves, towards the combustion chamber. These rarefraction waves pre-compress the new volume of air and gas; the temperature in the combustion chamber **20** still being high, the new air/gas volume is combusted without the need for ignition from the electrode **33**, and the process is repeated.

On start-up water flow into each of the tubes of walls **12** and **13** is initiated by first closing shut off valve **22** and opening shut off valve **22a** so that coolant is forced to travel through one wall of walls **12** and **13** only, and then opening valve **22** to force coolant through the other of walls **12** and **13**. This procedure ensures that there is flow in each wall of the combustor **10**.

Once water is flowing, the power switch **88** is turned on. Thermostat **74** will then call for heat. Terminals **4** and **5** on the sequencer **80** will close and the fan **40** will start. After 45 seconds terminals 1 and 3 on the sequencer **80** close and 24 volts is supplied to the ignition controller **50** through the high temperature limit switch **39**, the water flow switch **70**, and the air differential switch **68**. The water flow switch **70** is normally open. As soon as water flows through both coils it closes. Similarly, the air differential switch is normally open but as soon as the fan **40** comes on, the air differential switch closes. The high temperature limit switch is normally closed. As soon as the water temperature rises above that set by the end user, this switch opens and terminates the combustion thereby shutting down the boiler.

The ignition controller **50** sends 25,000 volts to the electrode **33** and 24 volts to the solenoid valve **52** through relay **43** which turns on the gas flow at the same time as the electrode **33** is energized. Gas flows to the mass flow regulator **44** through the now open solenoid valve **52**. From the regulator **44**, gas flows into the mixing chamber inside T-section **49**. The mixture enters the nozzle **19** and combustion chamber **20** where combustion takes place. Upon ignition, the spark will be stopped 2 seconds after the flame is sensed by the flame sensor **41**. Signals from the flame sensor **41** are sent to the ignition controller **50** and the solenoid valve **52** remains open as long as these signals are received.

At the start of each operation, the timer **66** relay will be at set point corresponding to a frequency of 40 Hz applied to the fan **40**. After 30 seconds the set point will move to that corresponding to a frequency of 65 Hz. When the ignition controller **50** is energized the following sequence of events takes place. Terminals 3 and **5** and **6** and **4** on relay **43** close, thus applying power to the timer relay **66**. For the first 30 seconds, the timer relay **66** will be at set point 40 Hz after which it moves to 65 Hz. Thermocouple **62** continuously measures the water temperature at the boiler outlet and these signals are sent to controller **64**. If the temperature measured by thermocouple **62** is below that of controller **64**, corresponding signals are sent to the speed controller **60** which controls the fan speed. The fan **40** is the operates at a high speed. If the temperature measured by thermocouple **62** approaches that measured by the temperature setpoint control **64**, corresponding signals are sent to the speed control **60** and the fan will speed will reduce correspondingly. Through sensing the A1-A2/G1-G2 ratio, a drop in A1-A2 results in the gas mass regulator reducing the gas flow. A reduction in gas flow causes a reduction in G1-G2 so the ratio A1-A2/G1-G2 remains constant. Thus the throttle system allows for optimum continuous operation of the boiler, significantly reducing the on/off cycles.

Should the spark fail to ignite the pulse combustor **10** as detected by the flame probe **41** within 5 seconds, the entire system is shut down with the gas valve **52** closing and the sensors being deactivated.

One example of a use for the present boiler system is to supply hot water to a hot water tank. The thermostat **74** would be used to measure the temperature of the water in the tank (not shown). Once the temperature of water in the tank fell below a preset limit, the thermostat **74** would close and the system would initiate startup and

then full operation. Thermocouple **62** would sense the temperature of the water being supplied to the tank by the boiler system. The boiler system would then supply water at the temperature established by the temperature setpoint control **64**.

Accordingly, while this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

I CLAIM:

1. A pulse combustor of a type having a combustion chamber in the center between first and second spaced apart walls and a tail pipe region between the plates which surrounds the combustion chamber and extends outwardly therefrom, comprising said first and second spaced apart walls each formed of hollow tubing wound in a spiral from the combustion chamber outwardly with the adjacent windings being contiguous, a fuel nozzle coupled to an inlet of said combustion chamber, and a spark generator in said combustion chamber located proximate said nozzle so as to ignite incoming fuel on startup, and wherein said tubing of each of said walls is adapted to conduct coolant.

2. A pulse combustor according to claim 1, wherein heat exchange coolant enters tubing of said first and second walls at the periphery thereof and exits from tubing leaving proximate said combustion chamber.

3. A pulse combustor according to claim 1, wherein adjacent windings of said tubing are welded together so that gas cannot leak out of said tail pipe region.

4. A pulse combustor according to claim 1, wherein said nozzle has a plurality of fuel passageways radially spaced around an axis thereof for conducting fuel therethrough and said spark generating means is an ignition rod having a central insulating rod extending into said nozzle and enclosing a central electrode extending out of an end of said insulating rod and which curves back so that its tip is proximate an exit of one of said fuel passageways.

5. A pulse combustor according to claim 1, wherein said walls are substantially circular.

6. A boiler having a coolant temperature control system which operates substantially continuously, comprising:

(a) a combustor for combusting an air/gas fuel mixture;

(b) a fan for providing a flow of air in an air line leading to said combustor;

(c) a speed control unit coupled to said fan and operative to control the speed thereof in response to a coolant temperature control signal;

(d) a gas line coupled to a source of gas;

(e) means for reducing the gas flow in response to a reduction of the air flow;

(f) means for mixing air from said air line with gas from said gas line and for directing the mixture to said combustor;

(g) heat exchange lines passing over said combustor to conduct coolant which absorbs heat from combustion therein; and

(h) a temperature sensor for measuring the temperature of coolant after passing through said combustor and transmitting the temperature measurement to said speed control unit,

wherein said speed control unit slows down the speed of said fan when the coolant temperature approaches a preset limit.

7. A boiler according to claim 6, wherein said means for reducing the gas flow includes:

(a) means for measuring a pressure differential in each of said gas and an air lines; and

(b) a gas mass flow regulator in said gas line operative to control the flow of gas depending upon the ratio of the differential pressure measurements in said air line to that in said gas line so that as the flow of air is reduced so is the flow of gas.

8. A boiler according to claim 6, wherein said temperature sensor is a thermocouple coupled to the coolant exiting from said combustor.

9. A boiler according to claim 6, including means for purging said combustor of spent exhaust gases prior to ignition.

10. A boiler according to claim 6, including an orifice in each of said air and gas lines and pressure sensing lines on each side of each of said orifices to detect the pressure and transmit it to said gas mass flow regulator.

11. A boiler according to claim 6, wherein said combustor is of a type having a combustion chamber in the center between first and second spaced apart walls and a tail pipe region surrounding said combustion chamber also between said walls surrounding said combustion chamber and extending outwardly therefrom.

12. A boiler according to claim 10, wherein said first and second spaced apart walls are each formed of hollow tubing wound in a spiral from the combustion chamber outwardly with the adjacent windings being contiguous, a fuel nozzle coupled to an inlet of said combustion chamber, and spark generating means in said combustion chamber located proximate said nozzle so as to ignite incoming fuel

on startup, and wherein said tubing of each of said first and second walls conducts coolant.

13. A pulse combustor according to claim 11, wherein heat exchange coolant enters said tubing of said first and second walls at the periphery thereof and exits from tubing leaving proximate said combustion chamber.

14. A pulse combustor according to claim 11, wherein adjacent windings of said tubing are welded together so that gas cannot leak out of said exhaust region.

15. A pulse combustor according to claim 11, wherein said nozzle has a plurality of fuel passageways radially spaced around the axis thereof for conducting fuel therethrough and said spark generating means is an ignition rod having a central insulating rod extending through said nozzle and enclosing an electrode which extends out from an end of said insulating rod and curves back so that its tip is proximate one of said gas passageways.

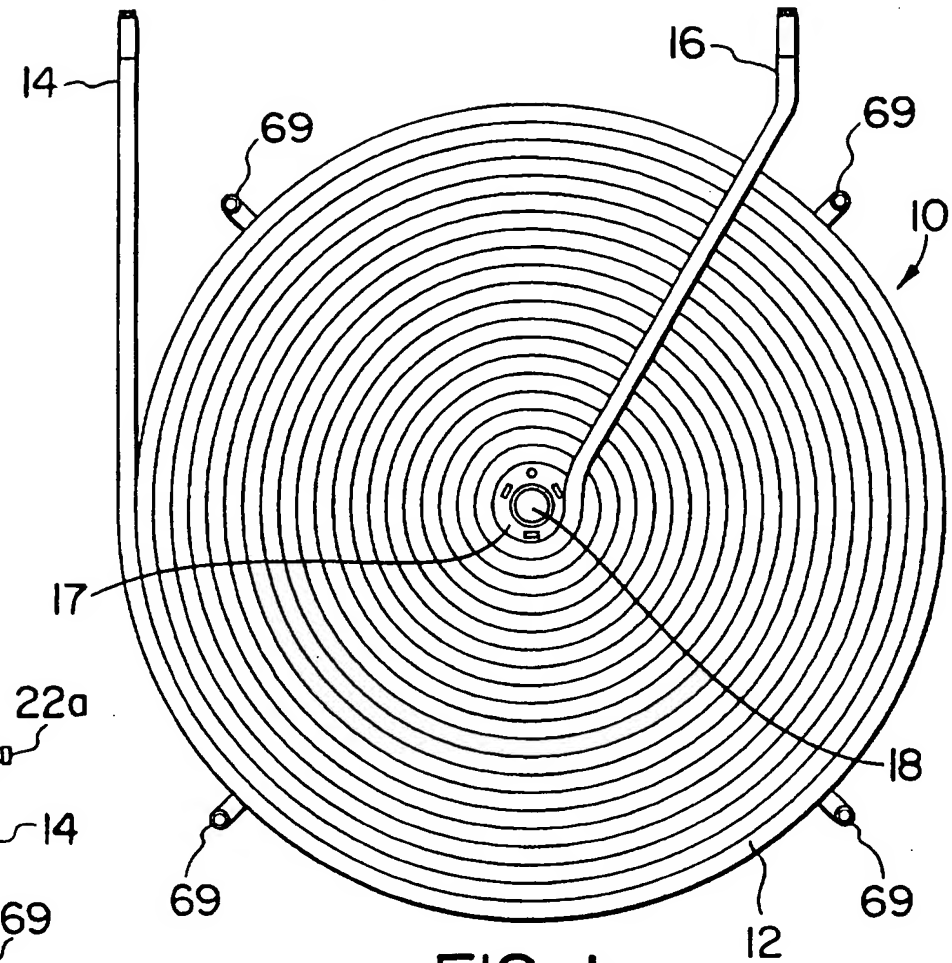

FIG. 1

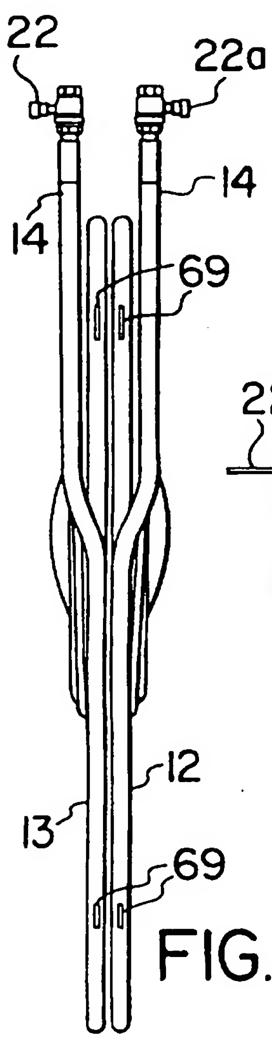

FIG. 3

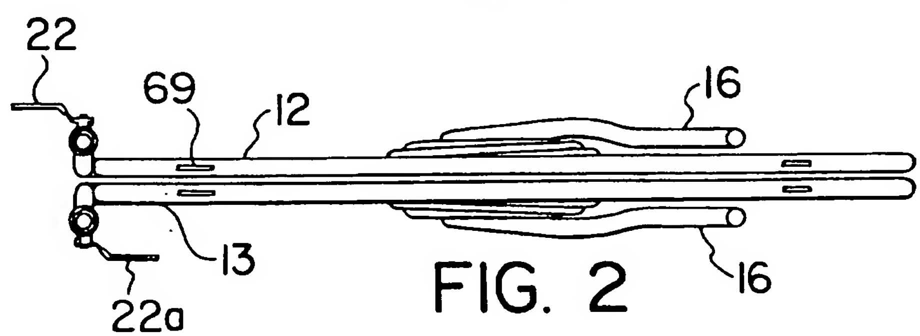

FIG. 2

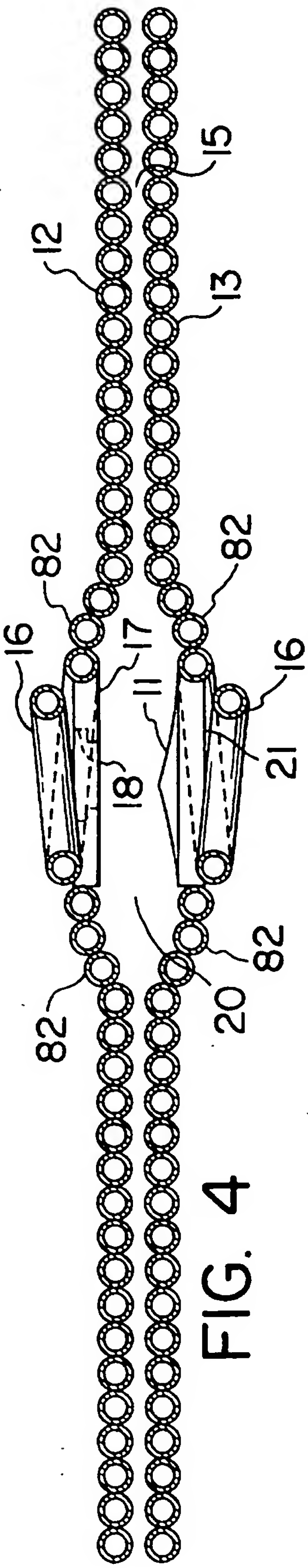

FIG. 4

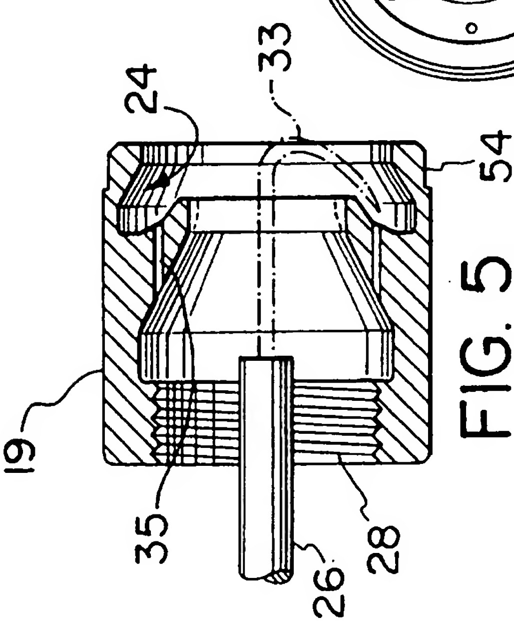

FIG. 5

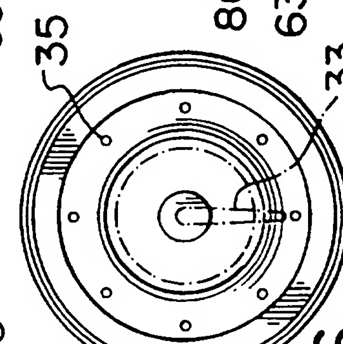

FIG. 6

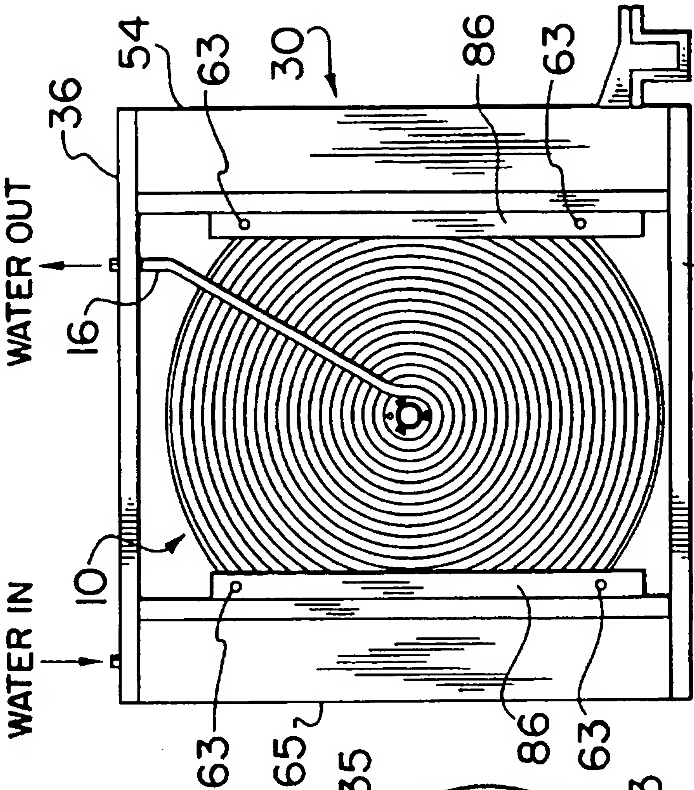

FIG. 7

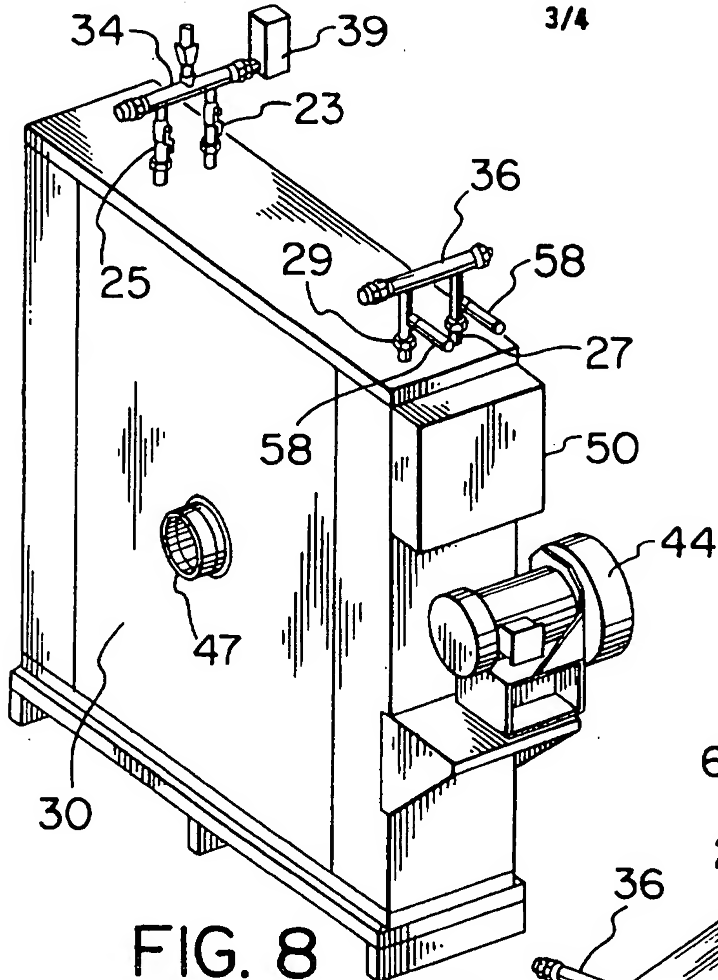

FIG. 8

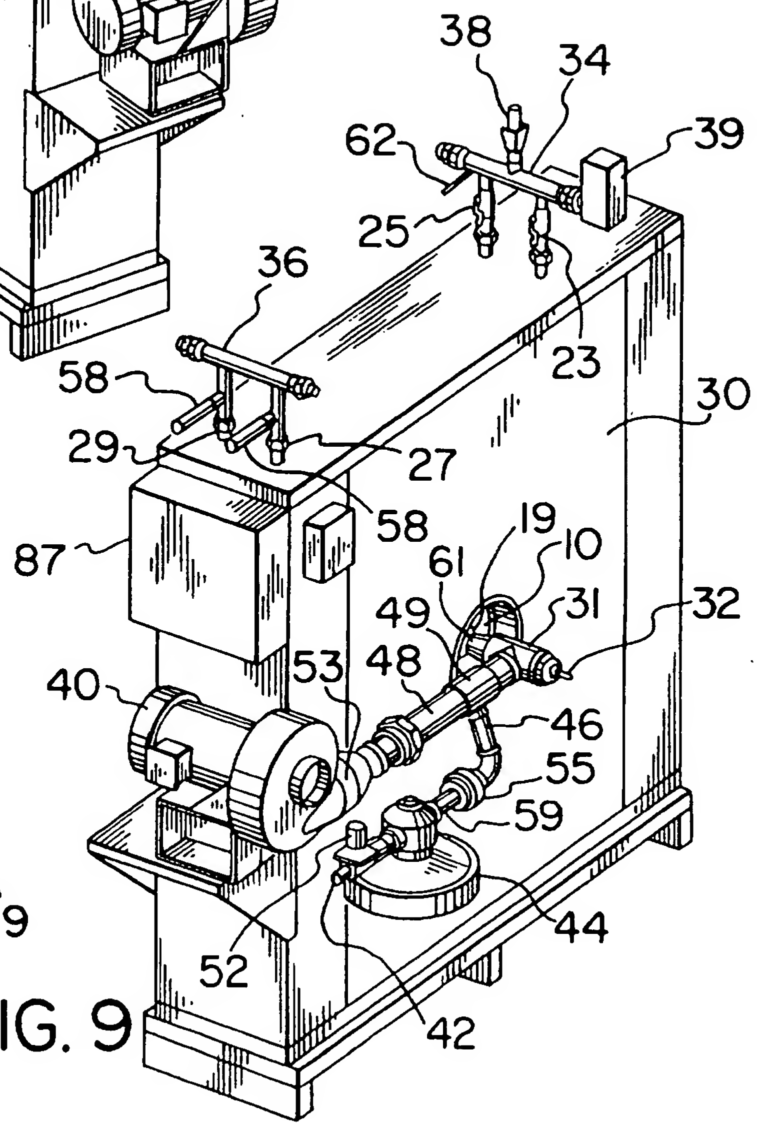

FIG. 9

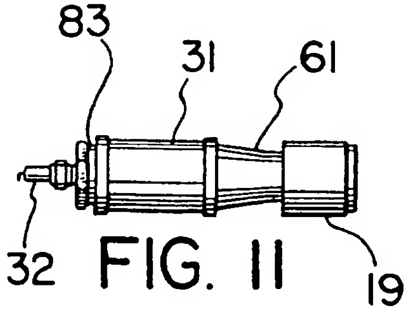

FIG. 11

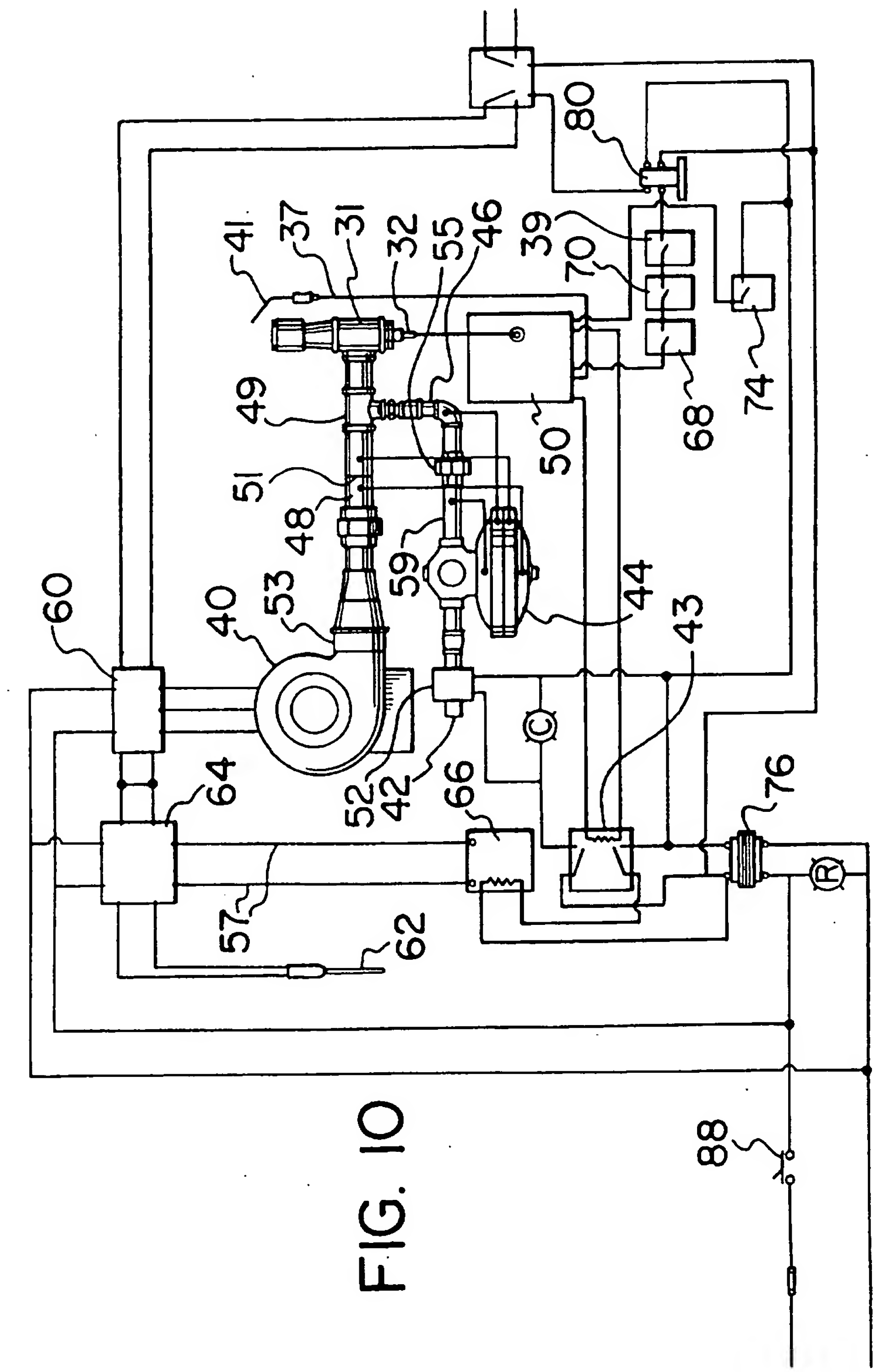
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FIG. 10

INTERNATIONAL SEARCH REPORT

Inter   nal Application No
PCT/CA 96/00136

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F23C11/04 F24H1/43

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F23C F24H F23M F23N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 968 244 (MOVASSAGHI MEHRZAD) 6 November 1990 cited in the application see the whole document ---	1-5
A	FR,A,589 096 (HALLOT) 22 May 1925 see the whole document ---	1,2
X	EP,A,0 317 178 (DAVAIR HEATING) 24 May 1989 see the whole document ---	6-10
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 183 (M-235), 12 August 1983 & JP,A,58 085016 (MATSUSHITA DENKI SANGYO KK), 21 May 1983, see abstract --- -/--	6,7,10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
27 September 1996	01. 10. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Coli, E

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 152 (M-391), 27 June 1985 & JP,A,60 029516 (MATSUSHITA DENKI SANGYO KK), 14 February 1985, see abstract ---	6,7,10
X	EP,A,0 532 339 (PALOMA KOGYO KK) 17 March 1993 see the whole document -----	6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA96/00136

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

CLAIMS (1-5),(11-15) : Pulse combustor provided with water cooled walls each formed of hollow tubing wound in spiral form and boiler wherein the combustor is of the pulsating type.
CLAIMS (6-10) : Boiler wherein a control unit speeds up or slows down on fan which supplies combustion air to a combustor of any kind.

1. [X] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[X] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

.nformation on patent family members

Inte onal Application No
PCT/CA 96/00136

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4968244	06-11-90	CA-A- 1319885	06-07-93
FR-A-589096	22-05-25	NONE	
EP-A-317178	24-05-89	NONE	
EP-A-0532339	17-03-93	JP-A- 5071709	23-03-93
		DE-D- 69210517	13-06-96
		ES-T- 2086668	01-07-96
		US-A- 5220864	22-06-93